Annual research report

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1 Service work

Every graduate student who intends to work at CDF (Collider detector at Fermilab) has to do some sort of service work for CDF collaboration at least for a year. In my case, I had done optical inspection of silicon layers the summer of 2000. After moving to Fermilab this January, I started to work on event merging with Todd Huffman from Oxford University.

1.1 Optical inspection for silicon layers

It was fairly interesting that I had visually inspected silicon layers with microscopes. SVX (Silicon Vertex detector which is to find vertices of particles) consists of six layers. Each layer has sensors, hybrids, and readout boards. They are well wired themselves with extremly thin wires. Some of them have flaws and broken wires. So it really saved time for me to inspect visually before going to test and burning. Also I had learned a lot about silicon detector while doing this work.

1.2 Event Merging

This is a tool, called EventMergeMods[1] to merge two different events. MC(Monte Calro) simulation to simulate $p\ \bar{p}$ events is not sufficient. For example Pythia which is MC generator widely used in HEP has wrong distribution of P_T which is the transverse component of space three momentum. So the purpose of event merging is to make MC realistic by means of overlaying real(minimum biased) data onto MC. It requires a lot of things to do. For example, every hits in COT (Central Outer Tracking which finds tracks of particles going through) and SVX should be overlayed. Furthermore, the energies of Electromagnetic and Hadronic Calorimeter should be merged. At this moment, the only working part of EventMergeMods is COT. The tracking efficiency study using event merging method is essencial. The successful merging will contaminate existing tracks. However, it will make more realistic MC data. So we need to understand how its efficiency is changed after merging.

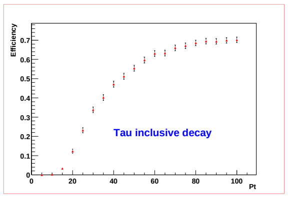
2 Understanding τ at CDF detector

This will be a part of my analysis. Rutgers group at CDF is interested in di-tau events. Higgs particle can provide the strong evidence of Standard Model as well as the first evidence of SUSY(Super Symmetry), which can be produced via gluon fussion or associated vector bosons. The branching fraction [2] of H $\rightarrow \tau\bar{\tau}$ is quite large compared with other channels[3]. The process Z $\rightarrow \tau\bar{\tau}$ is very similar with that channel so that it might be dominant backgroud. At this stage we need to better understand the behavior of τ itself at CDF detector. The branching fraction of $\tau \rightarrow hadrons$ is about 65%

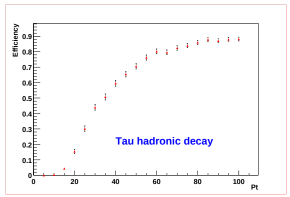
[1] CDF5524, written by Todd Huffman and Dongwook Jang

[2] Fermilab-Conf-00/279-T and SCIPP-00/37

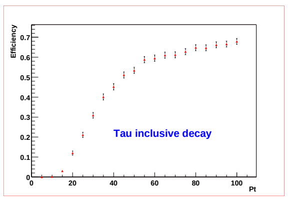
[3] Actually, H $\rightarrow b\bar{b}$ is the largest channel, but this channel might have large QCD background. H $\rightarrow \tau\bar{\tau}$ is the second largest one. Compared with the previous channel, it is relatively clean and considerate



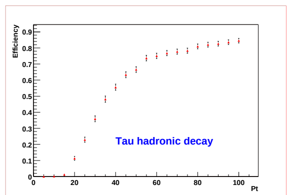
(a) inclusive decay, P_+



(b) hadronic decay, P_+



(c) inclusive decay, P_-



(d) hadronic decay, P_-

Figure 1: τ efficiency as a function of P_T; P_+ stands for τ polarization +1 while P_- for -1. The efficiency is defined as the ratio of the number of selected τ's to the number of generated ones. Inclusive means that the decay products include hadrons and leptons, while hadronic decay include only hadrons.

while that of $\tau \rightarrow leptons$ about 35% [4]. Since there is no way to identify leptonically decayed τ, we only consider hadronically decayed τ. There is a program tool to identify those τ's in each event, called TauFinder which is developed and maintained by Fedor Ratnikov, Rutgers postdoc.

2.1 τ efficiency study

I have studied the efficiency of τ identification from TauFinder with MC sample. Single particle gun was used for MC generator and 1000 events were generated in the step of 5 GeV/c P_T. There are cuts for Calorimeter energy and track momentum to select τ's. Figure 1 shows the efficiency as a function of P_T. The results are also consistent with Level 3 jet identification efficiency for real data; τ behaves like jets and its selection is also based on jet selection criteria.

[4]Review of Particle Physics, Particle Data Group, *The European Physical Journal C*, Volume 15, Number1-4 2000

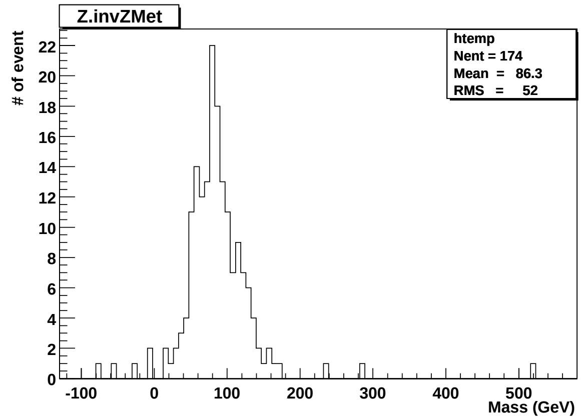


Figure 2: Reconstructed Mass of two τ candidates selected by TauFinder. Only events which have two τ's are selected.

2.2 Benchmarking for selected τ's

As I mentioned above, Z $\rightarrow \tau\bar{\tau}$ is a good starting point for background study and benchmarking. I generated $p\bar{p} \rightarrow$ Z with Z $\rightarrow \tau\bar{\tau}$. After MC data passing through detector simulation and physics reconstruction, I could select two τ's in each event, where TauFinderModule was used for hadronic τ reconstruction. Considering two neutrinos represented by $\not{E}$, I could find each neutrino's energy under assumption that its direction follows τ's and not back-to-back if sovling the following equations:

$$E^1_\nu sin\theta_1 cos\phi_1 + E^2_\nu sin\theta_2 cos\phi_2 = \not{E}_x$$

$$E^1_\nu sin\theta_1 sin\phi_1 + E^2_\nu sin\theta_2 sin\phi_2 = \not{E}_y$$

where, θ and ϕ are those of τ's.

Figure 2. shows the reconstructed mass of Z candidates. The width of distribution is quite large. I still need some corrections, for example $\not{E}_T$ correction, cut optimization, and ,if possible, Calorimeter merging.

3 Conclusion

There remain many things to do after all. Correct efficiency study is esscential for analysis related with τ. This could, also, give the developer feedback to improve the program. As for Eventmerging, I will work on to cover more parts of detectors.
In summary, I think that I had a successful academic year while staying at Fermilab.